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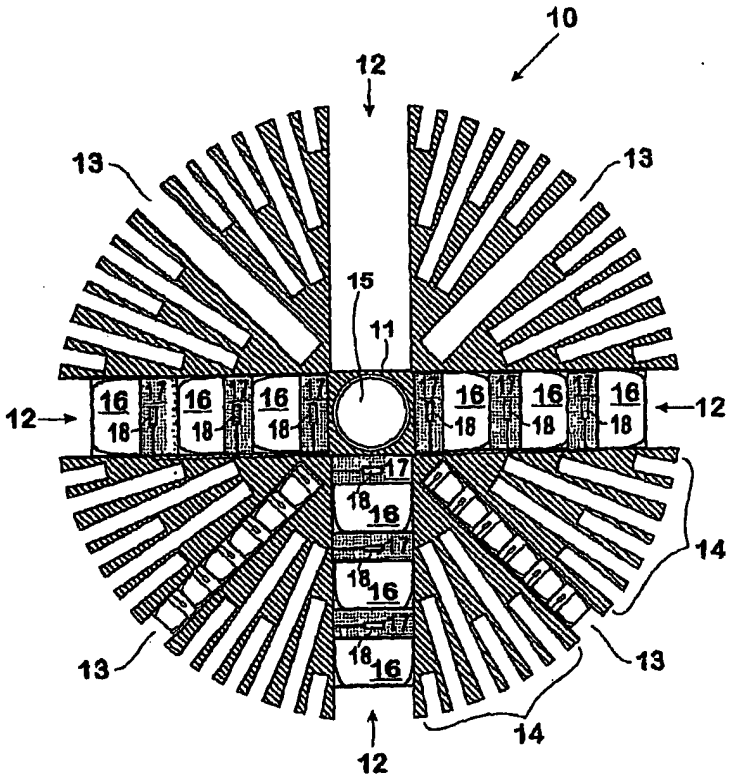
(54) Title: PROJECTILE FOR RADIALLY DEPLOYING SUB-PROJECTILES



(57) Abstract: A projectile (10) for firing from a barrel, said projectile including a multiplicity of barrel assemblies (12, 13, 14) radially disposed from the centre of mass of the projectile, wherein each of said multiplicity of barrel assemblies includes a plurality of sub-projectiles (16) axially disposed within a barrel; each of said sub-projectiles associated with a discrete propellent charge (17) for propelling a respective sub-projectile from the barrel, wherein said projectile is capable of selectively firing sub-projectiles (16), suitably with the aid of primers (18) each coupled to an electronic controller (15), to provide a predetermined pattern of deployed sub-projectiles. A defence system employing projectiles of the type described is also disclosed, together with a method for disguising the launch location of a projectile utilising divert propulsion.

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PROJECTILE FOR RADIALLY DEPLOYING SUB-PROJECTILES

BACKGROUND OF THE INVENTION

Field of the Invention

This present invention relates to the deployment of objects in the nature of projectiles and in particular, although not exclusively, to the formation of a predetermined pattern of deployed sub-projectiles by a parent projectile and to a projectile launching method for masking the launch location of a projectile.

Discussion of the Background Art

Projectiles that incorporate explosive charges have been used as fragmentation devices to deploy a plurality of fragments. In a simple form the casing of such a projectile fragments on detonation of the explosive charge such that individual fragments of the casing are deployed radially to form a fragmentation pattern roughly in the shape of the surface of a sphere.

In other configurations, the shape of the charge and the configuration of the casing may be varied to control the fragmentation pattern. However, such fragmenting projectiles produce a relatively thin, shell like fragment casing pattern. It is desirable that the depth of the fragmentation be able to be increased or controlled.

Such projectiles may be particularly suited to defending a designated area whilst avoiding rending the area dangerous after a threat situation has diminished, such as occurs with conventional minefields.

Existing defences to attacks typically include systems for acquiring and monitoring the trajectory of objects, including flying objects such as rockets and missiles. Examples of trajectory acquisition and monitoring systems are described in US Patent No. 4,622,458 to Boeck *et al* and US Patent No. 5,960,097 to Pfeiffer *et al*.

More recently, sophisticated defences to threats which include rounds launched at relatively high angles so as to be thrown or hurled at a target, such as characteristic of mortars, are capable of calculating the source of an attack by

deriving the location of a projectile launching apparatus from the trajectory of the projectiles.

SUMMARY OF THE INVENTION

Object of the Invention

It is an object of certain embodiments of the invention to provide a projectile that may be used to deploy sub-projectiles in a predetermined pattern that addresses the problems of the prior art, by providing increased or controlled fragmentation, or at least provides a useful choice for defence purposes.

It is a further object of certain embodiments of the invention to provide a defence system that has improved control over deployment of projectiles and does not render the defended area unsafe for later civilian use.

It is an object of other embodiments of the invention to provide a defence system capable of masking the location of a projectile launching apparatus by diverting projectile in flight whereby the location of the projectile launching apparatus is unable, or at least more difficult, to derive.

Disclosure of the Invention

According to a first form of the present invention, there is provided a projectile including a multiplicity of barrel assemblies radially disposed from the centre of mass of the projectile, wherein each of said multiplicity of barrel assemblies includes a plurality of sub-projectiles axially disposed within a barrel, wherein each of said sub-projectiles are associated with a discrete propellent charges for propelling a respective sub-projectile from the barrel, and wherein said projectile is capable of selectively firing sub-projectiles to provide a predetermined pattern of deployed sub-projectiles.

Preferably the projectiles of the present invention are particularly adapted for deployment by firing from the barrel of a gun, rather than self-propelled missiles or rockets that are launched from a tube or gantry. In other embodiments the projectiles of the invention may be deployed by dropping from a mobile platform, such as an aircraft or ship, utilising gravity for delivery or, alternatively, adapted for throwing by a soldier or protective services officer in a similar fashion to a conventional manually delivered grenade.

The projectiles of the invention suited to firing from a barrel may, in a first aspect, be used for intercepting and destroying incoming missiles, particularly of the high altitude ballistic type. In a second aspect, the present invention provides a method of intercepting a missile including the steps of determining the path of the missile, firing a projectile of the type herein described into the path of said missile, and firing selected sub-projectiles to form a predetermined pattern of sub-projectiles in and adjacent to the determined path of the missile.

The projectiles of the present invention may be used for vehicle self defence. A vehicle coming under attack, in particular from close range, may fire a projectile of the type herein described towards the attackers and deploy the sub-projectiles in a predetermined pattern amongst the attackers. In a third aspect, the present invention provides a self defence method for a vehicle from an attacking force including the steps of determining the location of the attacking force, firing a projectile of the type herein described adjacent to the determined location of the attacking force, and firing selected sub-projectiles to form a predetermined pattern of sub-projectiles in and adjacent to the determined location of the attacking force.

The projectiles of the present invention may be used for repelling an infantry advance. In a fourth aspect, the present invention provides a method of repelling an infantry including the steps of determining the location of the infantry, firing at least one projectile of the type herein described adjacent to the determined location of the infantry, and firing selected sub-projectiles to form a predetermined pattern of sub-projectiles in and adjacent to the determined location of the infantry.

The projectiles of the present invention may be used for forming airborne images, such as fireworks. In a fifth aspect, the present invention provides a method of forming airborne images including the steps of firing a projectile of the type herein described into the air, and firing selected sub-projectiles including image forming matter to form a predetermined pattern of image forming matter in the air.

The projectiles of the present invention may be used for fire fighting. In a sixth aspect, the present invention provides a method of fire fighting including the steps of determining the location of the fire, firing at least one projectile of the type herein described adjacent to the determined location of the fire, firing selected

sub-projectiles to form a predetermined pattern of sub-projectiles in and adjacent to the determined location of the fire, and deploying from the fired sub-projectiles a fire retardant.

The projectiles of the present invention may be used for generating a fuel-air explosion. In a seventh aspect, the present invention provides a method of generating a fuel-air explosion including the steps of selecting the desired location of the fuel-air explosion, firing at least one projectile of the type herein described adjacent to the desired location of the fuel-air explosion, firing selected sub-projectiles including a fuel to form a predetermined pattern of sub-projectiles, deploying the fuel from the fired sub-projectiles, firing selected sub-projectiles including detonators to form a predetermined pattern of sub-projectiles, detonating said detonators to generate a fuel-air explosion.

The projectiles of the present invention may be used for deploying a variety of payloads. In a eighth aspect, the present invention provides a method of deploying a payload including the steps of selecting a desired location for the delivery of a payload, firing at least one projectile of the type herein described adjacent to the desired location of the payload, firing selected sub-projectiles including said payload to form a predetermined pattern of sub-projectiles, and deploying said payload from the fired sub-projectiles.

The projectiles of the present invention may be used for defending a designated area. In a ninth aspect, the invention resides broadly in defence system for defending a designated area, said defence system including:-

at least one monitor for monitoring the designated area to detect any zone therein in which a new presence appears;

defence means capable of debilitating personnel present anywhere in a remote designated area wherein said defence means includes a weapon capable of firing projectiles wherein the projectiles include an array of barrel assemblies disposed radially from the centre of mass of the projectile, each barrel assembly having a plurality of secondary or sub-projectiles axially disposed within a barrel, which sub-projectiles are associated with discrete propellant charges for propelling said sub-projectiles sequentially from the barrel, wherein said array of barrel assemblies is capable of selectively firing the sub-projectiles from selected barrels whereby said projectile may deploy a predetermined pattern of sub-projectiles; and

communication means providing communication between the monitor and the defence for triggering selective activation of the defence for delivering a debilitating attack to the detected zone.

The monitors include one or more on-site sensors deployed in the designated area or remote-sensing means deployed remote from the designated area. Alternatively the monitoring means may include both on-site and remote sensing means.

The monitoring means may also provide a visual display of the monitored designated zone so that manual override means may be actuated, if desired, to enable manual control of the set defence means.

A number of secondary or sub-projectiles can be fired simultaneously from a plurality of barrels or in quick succession from the one barrel. In such arrangements the electrical signal may be carried externally of the barrel or it may be carried through the superimposed secondary projectiles which may clip on to one another to continue the electrical circuit through the barrel, or abut in electrical contact with one another. The sub-projectiles may carry the control circuit or they may form a circuit with the barrel.

The array of barrel assemblies may be arranged adjacent the leading end or the trailing end of the projectile for effecting changes in attitude of the projectile or medially for displacing laterally displacing the projectile. Alternatively the directional control system may include an array of barrel assemblies adjacent both leading and trailing ends of the projectile.

The or each array of barrel assemblies may fire a sub-projectile in a direction having a longitudinal component in order to provide a consequent addition to the kinetic energy of the projectile or a component in a direction tangential to the longitudinal axis of the missile in order to impart or change projectile rotation about its longitudinal axis. The barrel assembly may fire secondary projectiles across flight surfaces such as a wing to induce a further steering effect to the projectile. Alternatively barrel assemblies may extend through the aerofoil surfaces so as to fire in both directions. This may add structural strength to the aerodynamic design.

If desired, a separate array or opposing arrays of barrel assemblies may be provided to control projectile rotation about the longitudinal axis of the projectile.

The configuration of the arrays may include opposing pairs of barrel assemblies that are fired simultaneously to effect changes in rotation about the longitudinal axis of the projectile only. The sub-projectiles may be selectively actuated before and/or after firing secondary projectiles form the directional control system to negate or utilise the effects on the projectile of such rotation about its longitudinal axis.

In certain embodiments of the present invention energy required to change attitude and/or the flight direction of the parent projectile may be provided by the firing of sub-projectiles from one or more selected barrel assemblies.

According to a second form of the present invention, there is provided a method of masking the launch location of a projectile launching apparatus is provided. The method includes the steps of discharging at least one projectile from a barrel assembly, said barrel assembly having a barrel, a plurality of projectiles axially disposed within the barrel for operative sealing engagement with the bore of the barrel, and discrete propellant charges for propelling respective projectiles sequentially through the muzzle of the barrel and, whilst said at least one projectile is in flight, firing at least one sub-projectile from an array of divert propulsion assemblies incorporated therein, each divert propulsion assembly having a plurality of sub-projectiles axially disposed within a divert propulsion barrel, which sub-projectiles are associated with secondary discrete propellant charges for propelling said sub-projectiles sequentially from the divert propulsion barrel, wherein said array of divert propulsion barrel assemblies is capable of selectively firing the sub-projectiles from selected divert propulsion barrels whereby said projectile is accelerated by the reactionary force generated by said firing of sub-projectiles.

The overall shape of the sub-projectile is not narrowly critical as the sub-projectile is a mass against which the secondary propellant acts and exerts a reactionary force on the breech of the divert propulsion barrel. In the context of the present form of the invention, the breech may be formed by subsequent sub-projectiles remaining in the barrel in sealing engagement with the bore of the divert propulsion barrel. The reactionary force is transferred from the breech of the secondary or divert propulsion barrel to the projectile and results in an acceleration of the projectile.

The array of barrel assemblies may be disposed radially from the centre of mass of the projectile. Such configurations of barrel assemblies are particularly suited to objects that do not incorporate an in flight propulsion system, ie. rockets and missiles. The firing of sub-projectiles simply displaces the projectile and the projectile continues upon its trajectory, save for the displacement, the apparent trajectory.

The present invention has particular application to area denial systems wherein the area is subject to shelling by projectiles launched from a pod, such as a mortar box. It will of course be understood that the present invention also has application to disguising the firing location of other projectile launching or firing systems.

In a preferred embodiment the apparent trajectory may be selected to draw fire from the launch apparatus to other enemy positions.

The projectiles of the present invention advantageously employ barrel assemblies of the type described in International Patent Application Nos. PCT/AU94/00124 and PCT/AU96/00459. Such barrel assemblies include a barrel; a plurality of sub-projectiles axially disposed within the barrel for operative sealing engagement with the bore of the barrel, and discrete propellant charges for propelling respective sub-projectiles sequentially through the muzzle of the barrel.

The sub-projectiles may be round, conventionally shaped or dart-like and the fins thereof may be off-set to generate a stabilising spin as the dart is propelled from a barrel which may be a smooth-bored barrel. If required, the projectiles carrying the sub-projectiles may be substantially cylindrical, ovoid or spherical in shape.

The propellant charge may be form as a solid block to operatively space the sub-projectiles in the barrel or the propellant charge may be encased in metal or other rigid case which may include an embedded primer having external contact means adapted for contacting an pre-positioned electrical contact associated with the barrel. For example the primer could be provided with a sprung contact which may be retracted to enable insertion of the cased charge into the barrel and to spring out into a barrel aperture upon alignment with that aperture for operative contact with its mating barrel contact. If desired the outer case may be consumable or may chemically assist the propellant burn. Furthermore an

assembly of stacked and bonded or separate cased charges and sub-projectiles may be provided for reloading a barrel.

Each sub-projectile may include a head and extension means for at least partly defining a propellant space. The extension means may include a spacer assembly that extends rearwardly from the head and abuts an adjacent sub-projectiles assembly.

The spacer assembly may extend through the propellant space and the head whereby compressive loads are transmitted directly through abutting adjacent spacer assemblies. In such configurations, the spacer assembly may add support to the extension means that may be a thin cylindrical rear portion of the head. Furthermore the extension means may form an operative sealing contact with the bore of the barrel to prevent burn leakage past the sub-projectile.

The spacer assembly may include a rigid collar which extends outwardly to engage a thin cylindrical rear portion of a malleable head inoperative sealing contact with the bore of the barrel such that axially compressive loads are transmitted directly between spacer assemblies thereby avoiding deformation of the malleable head.

Complementary wedging surfaces may be disposed on the spacer assembly and head respectively whereby the head is urged into engagement with the bore of the barrel in response to relative axial compression between the spacer means and the head. In such arrangement the head and spacer assembly may be loaded into the barrel and there after an axial displacement is caused to ensure good sealing between the sub-projectile and barrel. Suitably the extension means is urged into engagement with the bore of the barrel.

The head may define a tapered aperture at its rearward end into which is received a complementary tapered spigot disposed on the leading end of the spacer assembly, wherein relative axial movement between the head and the complementary tapered spigot causes a radially expanding force to be applied to the sub-projectile.

The barrel may be non-metallic and the bore of the barrel may include recesses that may fully or partly accommodate the ignition means. In this configuration the barrel houses electrical conductors that facilitate electrical communication between the control means and ignition means. This configuration

may be utilised for disposable barrel assemblies that have a limited firing life and the ignition means and control wire or wires therefore can be integrally manufactured with the barrel.

A barrel assembly may alternatively include ignition apertures in the barrel and the ignition means are disposed outside the barrel and adjacent the apertures. A non-metallic outer barrel that may include recesses adapted to accommodate the ignition means may surround the barrel. The outer barrel may also house electrical conductors that facilitate electrical communication between the control means and ignition means. The outer barrel may be formed as a laminated plastics barrel that may include a printed circuit laminate for the ignition means.

The barrel assembly may have adjacent sub-projectiles that are separated from one another and maintained in spaced apart relationship by locating means separate from the sub-projectiles, and each sub-projectile may include an expandable sealing means for forming an operative seal with the bore of the barrel. The locating means may be the propellant charge between adjacent sub-projectiles and the sealing means suitably includes a skirt portion on each sub-projectile that expands outwardly when subject to an in-barrel load. The in-barrel load may be applied during installation of the sub-projectiles or after loading such as by tamping to consolidate the column of sub-projectiles and propellant charges or may result from the firing of an outer sub-projectile and particularly the adjacent outer sub-projectile.

The rear end of the sub-projectile may include a skirt about an inwardly reducing recess such as a conical recess or a part-spherical recess or the like into which the propellant charge portion extends and about which rearward movement of the sub-projectile will result in radial expansion of the sub-projectile skirt. This rearward movement may occur by way of compression resulting from a rearward wedging movement of the sub-projectile along the leading portion of the propellant charge it may occur as a result of metal flow from the relatively massive leading part of the sub-projectile to its less massive skirt portion.

Alternatively the sub-projectile may be provided with a rearwardly divergent peripheral sealing flange or collar which is deflected outwardly into sealing engagement with the bore upon rearward movement of the sub-projectile. Furthermore the sealing may be affected by inserting the sub-projectiles into a

heated barrel that shrinks onto respective sealing portions of the sub-projectiles. The sub-projectile may comprise a relatively hard mandrel portion located by the propellant charge and which cooperates with a deformable annular portion may be moulded about the mandrel to form a unitary sub-projectile which relies on metal flow between the nose of the sub-projectile and its tail for outward expansion about the mandrel portion into sealing engagement with the bore of the barrel.

The sub-projectile assembly may include a rearwardly expanding anvil surface supporting a sealing collar thereabout and adapted to be radially expanded into sealing engagement with the barrel bore upon forward movement of the sub-projectile through the barrel. In such a configuration it is preferred that the propellant charge have a cylindrical leading portion that abuts the flat end face of the sub-projectile.

The sub-projectiles may be adapted for seating and/or location within circumferential grooves or by annular ribs in the bore or in rifling grooves in the bore and may include a metal jacket encasing at least the outer end portion of the sub-projectile. The sub-projectile may be provided with contractible peripheral locating rings which extend outwardly into annular grooves in the barrel and which retract into the sub-projectile upon firing to permit its free passage through the barrel.

The electrical ignition for sequentially igniting the propellant charges of a barrel assembly may preferably include the steps of igniting the leading propellant charge by sending an ignition signal through the stacked sub-projectiles, and causing ignition of the leading propellant charge to arm the next propellant charge for actuation by the next ignition signal. Suitably all propellant charges inwardly from the end of a loaded barrel are disarmed by the insertion of respective insulating fuses disposed between normally closed electrical contacts.

Ignition of the propellant may be achieved electrically or ignition may utilise conventional firing pin type methods such as by using a centre-fire primer igniting the outermost sub-projectile and controlled consequent ignition causing sequential ignition of the propellant charge of subsequent rounds. Controlled rearward leakage of combustion gases or controlled burning of fuse columns extending through the sub-projectiles may achieve this.

In other embodiments, the ignition is electronically controlled with respective propellant charges being associated with primers that are triggered by distinctive ignition signals. For example the primers in the stacked propellant charges may be sequenced for increasing pulse width ignition requirements whereby electronic controls may selectively send ignition pulses of increasing pulse widths to ignite the propellant charges sequentially in a selected time order. Preferably however the propellant charges are ignited by a set pulse width signal and burning of the leading propellant charge arms the next propellant charge for actuation by the next emitted pulse.

Suitably in such embodiments all propellant charges inwardly from the end of a loaded barrel are disarmed by the insertion of respective insulating fuses disposed between insertion of respective insulating fuses disposed between normally closed electrical contacts, the fuses being set to burn to enable the contacts to close upon transmission of a suitable triggering signal and each insulating fuse being open to a respective leading propellant charge for ignition thereby.

In certain embodiments the barrel assemblies may be of the low-pressure type, which fire grenade-like sub-projectiles although high muzzle pressure barrel assemblies may be used. Respective barrel assemblies may be loaded with different sub-projectiles and the barrel assemblies may have different size bores for accommodating different size sub-projectiles.

Suitably each sub-projectile includes a trailing collar captively mounted to the sub-projectile body and when stored in the barrel, extends rearwardly to wedge against the nose portion of a trailing sub-projectile body. Suitably a shallow wedge provides the wedging action whereby, in use, the trailing end of the collar is expanded into operative sealing engagement with the barrel.

The trailing collar may be mounted for limited axial movement relative to the sub-projectile body and the leading end of the collar formed with an annular sealing face engageable with a complementary face formed on the sub-projectile body whereby rearward movement of the sub-projectile body resulting from the reaction of propellant gases thereon forces the its complementary face into sealing engagement with the annular sealing face at the leading end of the collar.

The complementary face and the annular sealing face may extend substantially radially and be formed with complementary sealing features thereon. However it is preferred that these faces are complementary part-conical sealing faces which wedge into tight sealing engagement with one another. The leading end part may also be expandable into operative sealing engagement with the barrel. Suitably however the wedging between the part-conical faces are relatively steep faces whereby the leading end of the collar is not expanded into operative sealing engagement with the barrel by the wedging action.

In low pressure applications, preferably each sub-projectile is associated with a high-pressure propellant chamber that exhausts to respective low-pressure propulsion chambers formed between the adjacent sub-projectiles for efficient low muzzle velocity operation. The high-pressure propellant chambers may be formed integrally with the sub-projectile body or the trailing collar or be provided at the exterior of the barrel to communicate therewith through ports provided through the barrel wall.

Suitably the configuration of the space into which the ignited propellant propagates and the propellant properties are such that only low barrel pressures occur in use, such as in the order of 2,000psi to 5,000psi. Typically the collar is such that in its relaxed attitude it does not prevent free movement of the projectile through the barrel either for loading purposes or during firing.

A pressure pad is mounted on the housing inwardly of the open trailing end. The collar is relocated from the engaged condition upon ignition of the propellant and is retained in a relaxed condition by the pressure pad for passage through the barrel and out the muzzle of the barrel.

The projectile may be of the conventional type and be conventionally fired or preferably be adapted to be fired from a barrel assembly that includes a plurality of projectiles axially disposed within a barrel wherein each of said projectiles are associated with a discrete propellant charges for propelling said projectiles from the barrel.

The projectile, in a preferred form, may be generally spherical in shape and have the multiplicity of barrel assemblies radially disposed from the centre of the sphere. The barrel assemblies may be the same or different. For example whilst large diameter barrels may be disposed from the centre of the spherical projectile.

Smaller diameter barrels may be positioned between the larger diameter barrels to provide the maximum sub-projectile density in the projectile. It may be desirable to provide the projectile with the maximum barrel packing density and hence firepower. Alternatively it may be desirable to provide the projectile with a variety of barrel bores in order that sub-projectiles of a variety of calibres may be utilised.

The projectile may be a saboted projectile for advantageous deployment. A spherical projectile may be saboted into a more convenient shape for firing from a conventional deployment system such as in the form of a conventional munition. Alternatively if it is desirable to provide increased muzzle velocity a saboted projectile can accommodate an increased propellant charge without require a prohibitive barrel length.

Barrel assemblies that are radially disposed from the centre of mass of the projectile allow the projectiles to deploy the sub-projectiles in a regular and readily controlled manner. Barrel assemblies that are radially disposed from the centre of mass of the projectile allow the projectile to maintain its attitude. By deploying sub-projectiles in a manner that results in zero resultant reactive force on the projectile the projectile may be maintained on its desired trajectory

A number of sub-projectiles can be fired simultaneously, or in quick succession. In such arrangements the electrical signal may be carried externally of the barrel or it may be carried through the superimposed sub-projectiles that may clip on to one another to continue the electrical circuit through the barrel, or abut in electrical contact with one another. The sub-projectiles may carry the control circuit or they may form a circuit with the barrel.

The projectile of the present invention may deploy the sub-projectiles in a predetermined pattern that may be selected for particular applications. For example, in order to intercept and destroy an incoming missile, it is desirable to deploy the sub-projectiles in a manner that maximises the likelihood of the missile impacting with one or more of the sub-projectiles. Fragmentation systems have been employed to scatter fragments of a projectile in the path of an incoming missile. However, systems such as this that explode the projectile generally produce a band of fragments that disperse and form an expanding spherical shell. The projectiles may deploy the sub-projectiles of the invention in a more homogeneous manner throughout the space occupied by the predetermined

pattern. By controlling the timing of the firing of the sub-projectiles it is possible to establish a three dimensional "frag" pattern having a substantially homogeneous distribution of sub-projectiles. Alternatively, the sub-projectiles may be concentrated in areas where the missile is more likely to be intercepted so as to increase the effectiveness of the deployed sub-projectiles.

The sub-projectile may contain material for forming air-borne images. The image forming material may include, for example, explosive matter, incendiary matter, incandescent or luminous matter or other matter to provide a highly visible temporary image. Alternatively, the image forming matter may include smoke, gas, particles or sheets or strips, such as in the nature of chaff, or other material capable of being dispersed to form, an image. Accordingly, the projectile of the invention may be advantageously employed to launch counter-measures from military aircraft. The image forming matter may also include means for slowing its descent from its dispersed position, such as a parachute and the like.

The sub-projectiles may be arranged in the barrel assemblies such that once fired and the image forming matter deployed, the desired temporary airborne image is formed. Sub-projectiles containing different image forming matter, either differing in colour or form, may be sequentially loaded into each barrel assembly.

The image forming matter may be deployed, for example, by explosive means, by stored energy or by separation of separable parts of the sub-projectile to expose the image forming matter or by any other suitable dispersing means.

The image forming matter may be contained within a housing that may be of any suitable configuration that provides for the containment of the image forming matter and is suitably configured for engagement with the trailing end of the expandable collar of the preceding projectile. Preferably the housing is of the type employed with grenade-like projectiles, having relatively squat shape although projectiles having elongate housings could also be employed.

The housing may suitably be formed from biodegradable material and/or combustible material. This material may be based on a natural product such as woodchip or a synthetic material, such as a biodegradable polymer.

Advantageously the projectiles of the present invention may deploy selected sub-projectiles in order to control the course of the projectile. Such deployment may be understood as a divert propulsion system and may be used to

affect limited corrections to the position of the projectile for the deployment of the remainder of the sub-projectiles in the desired pattern.

The projectiles of the present invention may suitably be employed in a defence system of the type described in the present applicant's International Patent Application No. PCT/AU00/01351.

BRIEF DETAILS OF THE DRAWINGS

In order that this invention may be more readily understood and put into practical effect, reference will now be made to the accompanying drawings which illustrate preferred embodiments of the invention and wherein:

FIG. 1 is a cross sectional illustration of a projectile according to a preferred embodiment of the present invention;

FIG. 2 is a cross sectional illustration of a saboted projectile for use in a barrel assembly having a plurality of axially disposed saboted projectiles;

FIG. 3 is a cross sectional illustration of the firing of saboted projectiles as shown in FIG. 2;

FIG. 4 is a side elevational diagram of a defence system according to a further embodiment of the invention; and

FIG. 5 is a perspective diagram of the defence system of the further embodiment.

DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. 1 shows a projectile 10 having six (6) large bore barrels 12 of a convenient calibre, although only four (4) are shown in this cross sectional representation. The remaining two (2) large bore barrels (extending perpendicularly to the page) are depicted at 11. The cross sectional representation also shows four (4) medium bore barrels 13 of medium calibre, and forty-eight (48) small bore barrels 14 of relatively small calibre. The large bore 12, medium bore 13 and small bore 14 barrels each contain a plurality of axially disposed sub-projectiles 16, as represented on the drawing. The sub-projectiles are associated with propellant charges 17 and ignition means 18, which ignition means may be sequentially fired under the control of an electronic controller 15. In some

embodiments, the projectile 10 may also contain an explosive charge for terminal detonation.

The electronic controller 15, which is disposed in the centre of the projectile 10 behind the barrels 11, 12 in this embodiment, may include sensors for tracking an incoming missile when in-flight. Alternatively, the electronic controller 15 may receive firing instructions from a remote tracking station via a communications link. The sequenced firing of a number of the sub-projectiles may thus be coordinated to provide an improved likelihood of impacting with the targeted incoming missile or similar threat.

FIG. 2 shows a projectile of the type shown in FIG. 1 with a sabot 20, wherein the sub-projectiles are omitted for reasons of clarity. The projectile 10 is retained in a barrel within the sabot 20. The sabot includes a forward sabot portion 21, a rearward sabot portion 22 and an expanding sleeve 23 disposed about a chamfered rear surface 24 of the rearward sabot portion. The detonation and firing of a propellant charge in front of the forward sabot portion 21 forces the rearward sabot portion 22 against the expandable sleeve 23 and causes the expandable sleeve to sealably engage with the bore of a parent barrel.

FIG. 3 shows a series of projectiles 10 being fired from a parent barrel assembly 30, having a plurality of parent barrels 31, 32 and 33. Projectile 10A has been fired from barrel 33 and has discarded its sabot (not shown). Projectile 10B has been fired from barrel 32 and the sabot 20 is shown in the process of being discarded. The expandable sleeve 23 has detached from the rearward sabot 22 and the rearward sabot 22 has also detached from projectile 10B. Forward sabot 21 has similarly detached from the projectile 10B. Projectile 10C has been more recently fired from barrel 31 and the sabot 20 has commenced detachment from projectile 10C.

Referring to FIGs. 4 and 5, it will be seen that a designated area 40 to be defended is monitored by an array of field sensors 41 distributed over the designated area and which may be of any suitable type such as pressure, acoustic or seismic type sensors.

The illustrated defence system 42 employs a weapon taking the form of a pair of grenade boxes 43 each using the barrel assemblies 30 and coupled to a remote sensing means 44 and to a receiver unit 49 associated with the field

sensors 41. The remote sensing means 44, which in the embodiment is tower mounted, is adapted to sweep the designated area 40 using electro-optical or microwave techniques to monitor any intrusion into the designated area by a personnel, vehicles or other intruder.

The receiver unit 49 is adapted to receive signals from the array of field sensors 41, using a radio frequency (RF) communications link in the embodiment (although a cable link may be employed in the alternative). Upon any sensed intrusion in the area 40, the zone of the intrusion will be isolated for targeting by projectiles 10 fired from the grenade boxes 43. Thus the designated area 40 is monitored by either or both of the array of field sensors 41 or by the remote sensing means 44.

It is desirable that each grenade box 43 is located in a substantially concealed position, such as a hole in the ground. Once set up, the hole in which the grenade box 43 is placed may be back filled without causing any detrimental effects to the operation of the barrel assemblies 30 therein. In other arrangements, the grenade box 43 may be conveniently concealed in foliage and adjusted by screw jacks 48 associated with a support base 47 for the grenade box.

A subsidiary control circuit 43a (see FIG. 5), provided as a plug-in connection to the grenade box 43, is fitted on-site but not during transport so as to maintain safety of the weapon during transport. Once fitted with the control circuit 43a, the weapon is armed and ready to fire in accordance with controls provided by the sensor unit 44 and/or the receiver unit 49. The control circuit is suitably able to communicate with the electronic controller 15 in a respective projectile, as required.

A central remote sensor 44 in Fig. 2 is linked to multiple grenade boxes 43 via respective control circuits 43a. In use, if an intrusion into the detected area is detected at a zone, such as any one of the zones indicated as 50 to 59, the selected grenade box 43 can be activated to fire one or more projectiles 45 into that particular zone. The sub-projectiles may be subsequently fired a respective projectile 45, either in accordance with a pre-selected sequence or under remote control, to produce a predetermined pattern of deployed sub-projectiles. The pattern of sub-projectiles is desirably chosen in accordance with the nature of the intruder.

An intruder coming into the designated area 40 may be in any of a number of forms and may include a plurality of intruders. An intruder may be military personnel, in the form of an infantryman or foot soldier. Alternatively, the intruder may be a manned or unmanned vehicle such as an armoured car or tank. The intruder may have sophisticated defence systems that may track the trajectory of an incoming round and calculate the location of the launch apparatus, thereby enabling an attack on the previously hidden launch apparatus. The defence system of the embodiment allows the trajectory of the projectile to be diverted in flight by launching sub-projectiles, thereby enabling an apparent trajectory to be tracked and the true location of the launch apparatus to be masked. If feasible, the apparent trajectory may be selected to draw enemy fire directed at the defence system 42 to other enemy positions.

Whilst the above defence system is land based, another aspect of the invention concerns projectiles that might be termed water mines. These water mines may be launched from a ship and remain floating in the water and activated for either remote control or autonomous operation using on-board sensor systems, including radar, sonar or infra-red sensors. A line of such mines, incorporating stabilising or anchoring means such as a suspended weight, could be laid to provide a marine defence perimeter capable or being activated or deactivated as required.

In another mode of deployment, projectiles of the invention may be dropped from an aircraft such as a helicopter. Stabilising or anchoring means, such as spikes, could be provided to fix retain projectiles in one position on the ground. A first layer of sub-projectiles could include sensor systems for launching to detect the presence of enemy troops or vehicles, which could be engaged as required by grenades in subsequent layers in individual barrels of the projectile. Further sensors may be provided in other layers for surveying the result of an engagement.

A further mode of deployment is to provide a projectile of a size that can be conveniently hand-held and deployed by throwing, similar to a conventional grenade. However, the incorporation of sub-projectiles in barrels in the hand-delivered projectile enables it to be used in a repeating mode using a pre-set time delay or a remote control facility. This may provide certain advantages in

engagements that occur in closed spaces, such as in urban warfare or topography including caves. The sub-projectiles may incorporate non-lethal rounds and an audio annunciation system for warning, perhaps in a siege situation, that additional rounds are capable of being fired if the miscreants involved fail to surrender immediately.

Projectiles of the invention may be carried into space and delivered into orbit around a planet or moon as required, effectively comprising a satellite. Since the barrel assemblies can be radially dispersed within a generally spherical body, they function very effectively to correct the position of the satellite in orbit, protect a zone around a valuable satellite from space junk, meteorites and the like, or to engage an enemy space vehicle or satellite. A change of position can be undertaken much more rapidly in the low gravity environment because of the energy liberated by firing a solid sub-projectile, rather than a burst of gas as in conventional satellites. The satellite projectiles are suitably constructed so as to be consumed by combustion upon re-entry into the atmosphere subsequent to orbital decay.

In one particular form, the satellite may comprise a super-projectile which in turn may deploy projectiles of the present invention from radially disposed barrel assemblies therein, and those deployed projectiles may themselves be equipped with sub-projectiles, thus providing a two tiered defence system. This two tiered system of course may be employed in other applications of suitable scale.

It will of course be realised that the above has been given only by way of illustrative example of the invention and that all such modifications and variations thereto as would be apparent to persons skilled in the art are deemed to fall within the broad scope and ambit of the invention as is herein set forth in the following claims.

CLAIMS

1. A projectile for launching at a target, said projectile including:

a multiplicity of barrel assemblies radially disposed from the centre of mass of the projectile, wherein each of said multiplicity of barrel assemblies includes a plurality of sub-projectiles axially disposed within a barrel;

each of said sub-projectiles associated with a discrete propellent charge for propelling a respective sub-projectile from the barrel, wherein said projectile is capable of selectively firing sub-projectiles to provide a predetermined pattern of deployed sub-projectiles.

2. The projectile of claim 1 wherein the projectile is adapted to be fired from a barrel.

3. The projectile of claim 2 wherein the plurality of sub-projectiles is axially disposed within the barrel for operative sealing engagement with the bore of the barrel.

4. The projectile of any one of claims 1 to 3 that is generally spherical in shape and have the multiplicity of barrel assemblies radially disposed from the centre of the sphere.

5. The projectile of claim 4 having a variety of different barrel diameters in order that sub-projectiles of a variety of calibres may be utilised.

6. The projectile of either claim 4 or claim 5 wherein relatively large diameter barrels are disposed from the centre of the spherical projectile and relatively small diameter barrels are positioned between the larger diameter barrels to maximise sub-projectile density in the projectile.

7. The projectile of any one of claims 1 to 6 wherein the projectile includes a sabot.

8. The projectile of any one of claims 1 to 7 further including an electronic controller for controlling ignition of the propellant charges.

9. The projectile of claim 8 wherein a number of sub-projectiles can be fired simultaneously or in quick succession.

10. The projectile of either claim 8 or claim 9 wherein the multiplicity of barrel assemblies are arranged such that the sub-projectiles may be deployed with minimal resultant reactive force on the projectile, allowing the projectile to maintain a desired trajectory.

11. The projectile of claim 8 further including sensors for tracking a threat or intruder.

12. The projectile of claim 8 wherein said electronic controller receives firing instructions from a remote tracking station via a communications link.

13. The projectile of any one of claims 1 to 12 wherein sub-projectiles are deployed in order to alter or control the trajectory of the projectile.

14. A method of intercepting a missile, said method including the steps of determining the path of the missile; firing a projectile as claimed in any one of claims 1 to 13 into the path of said missile; and firing selected sub-projectiles to form a predetermined pattern of sub-projectiles in and adjacent to the determined path of the missile.

15. A self defence method for a vehicle from an attacking force including the steps of determining the location of the attacking force; firing a projectile as claimed in any one of claims 1 to 13 adjacent to the determined location of the attacking force; and firing selected sub-projectiles to form a predetermined pattern of sub-projectiles in and adjacent to the determined location of the attacking force.

16. A method of repelling an infantry including the steps of determining the location of the infantry; firing at least one projectile as claimed in any one of claims 1 to 13 adjacent to the determined location of the infantry; and firing selected sub-projectiles to form a predetermined pattern of sub-projectiles in and adjacent to the determined location of the infantry.

17. A method of forming airborne images including the steps of firing a projectile as claimed in any one of claims 1 to 13 into the air; and firing selected sub-projectiles including image forming matter to form a predetermined pattern of image forming matter in the air.

18. A method of fire fighting including the steps of determining the location of the fire; firing at least one projectile as claimed in any one of claims 1 to 13 adjacent to the determined location of the fire; firing selected sub-projectiles to form a predetermined pattern of sub-projectiles in and adjacent to the determined location of the fire; and deploying from the fired sub-projectiles a fire retardant.

19. A method of generating a fuel-air explosion including the steps of selecting the desired location of the fuel-air explosion; firing at least one projectile as claimed in any one of claims 1 to 13 adjacent to the desired location of the fuel-air explosion; firing selected sub-projectiles including a fuel to form a predetermined pattern of sub-projectiles; deploying the fuel from the fired sub-projectiles; firing selected sub-projectiles including detonators to form a predetermined pattern of sub-projectiles; detonating said detonators to generate a fuel-air explosion.

20. A method of deploying a payload including the steps of selecting a desired location for the delivery of a payload; firing at least one projectile as claimed in any one of claims 1 to 13 adjacent to the desired location of the payload; firing selected sub-projectiles including said payload to form a predetermined pattern of sub-projectiles; and deploying said payload from the fired sub-projectiles.

21. A defence system for defending a designated area, said defence system including:-

at least one monitor for monitoring the designated area to detect any zone therein in which a new presence appears;

defence means capable of debilitating an intruder present anywhere in a remote designated area wherein said defence means includes a weapon capable of firing projectiles, wherein the projectiles include:

an array of barrel assemblies disposed radially from the centre of mass of the projectile, each barrel assembly having a plurality of secondary or sub-projectiles axially disposed within a barrel, which sub-projectiles are associated with discrete propellant charges for propelling said sub-projectiles sequentially from the barrel, and

said array of barrel assemblies is capable of selectively firing the sub-projectiles from selected barrels whereby said projectile may deploy a predetermined pattern of sub-projectiles; and

communication means providing communication between the monitor and the defence for triggering selective activation of the defence for delivering a debilitating attack to the detected zone.

22. The defence system of claim 21 wherein the monitors include one or more on-site sensors deployed in the designated area or remote-sensing means deployed remote from the designated area.

23. The defence system of either claim 21 or claim 22 wherein the monitoring means provide a visual display of the monitored designated zone so that manual override means may be actuated, if desired, to enable manual control of the weapon.

24. The defence system of any of claims 21 to 23 wherein a number of sub-projectiles can be fired simultaneously from a plurality of barrels or in quick succession from the one barrel.

25. The defence system of claim 24 wherein an electrical firing signal is carried through a circuit externally of the barrel.

26. The defence system of claim 24 wherein an electrical firing signal is carried through superimposed sub-projectiles.

27. The defence system of claim 26 wherein the sub-projectiles clip on to one another to continue an electrical circuit through the barrel.

28. The defence system of claim 26 wherein the sub-projectiles abut in electrical contact with one another.

29. The defence system of claim 24 wherein the sub-projectiles each carry a control circuit.

30. The defence system of any one of claims 21 to 29 wherein the array of barrel assemblies includes barrels arranged adjacent an end of the projectile for effecting changes in attitude of the projectile.

31. The defence system of any one of claims 21 to 30 wherein the array of barrel assemblies includes barrels arranged medially for laterally displacing the projectile.

32. The defence system of any one of claims 21 to 31 wherein each array of barrel assemblies may fire a sub-projectile in a direction having a longitudinal component in order to provide a consequent addition to the kinetic energy of the projectile.

33. The defence system of any one of claims 21 to 31 wherein each array of barrel assemblies may fire a sub-projectile in a direction having a component in a direction tangential to the longitudinal axis of the projectile in order to impart or change projectile rotation about its longitudinal axis.

34. The defence system of any one of claims 21 to 33 wherein at least some of the barrel assemblies may fire secondary projectiles across flight surfaces such as a wing to induce a further steering effect to the projectile.

35. The defence system of any one of claims 21 to 33 wherein at least some of the barrel assemblies extend through aerofoil surfaces so as to fire in both directions.

36. The defence system of any one of claims 21 to 33 wherein a separate array or opposing arrays of barrel assemblies are provided to control projectile rotation about the longitudinal axis of the projectile.

37. The defence system of claim 36 wherein the configuration of said arrays include opposing pairs of barrel assemblies that are fired simultaneously to effect changes in rotation about the longitudinal axis of the projectile only.

38. The defence system of any one of claims 21 to 37 wherein energy required to change attitude and trajectory of the projectiles is provided by the firing of sub-projectiles from selected barrel assemblies.

39. A method of masking the launch location of a projectile launching apparatus, said method including the steps of:

(a) discharging at least one projectile from a barrel assembly, said barrel assembly having a barrel, a plurality of projectiles axially disposed within the barrel for operative sealing engagement with the bore of the barrel, and discrete propellant charges for propelling respective projectiles sequentially through the muzzle of the barrel; and

(b) whilst said at least one projectile is in flight firing at least one sub-projectile from an array of divert propulsion assemblies incorporated therein, each divert propulsion assembly having a plurality of sub-projectiles axially disposed within a divert propulsion barrel, which sub-projectiles are associated with secondary discrete propellant charges for propelling said sub-projectiles sequentially from the divert propulsion barrel; wherein

(c) said array of divert propulsion barrel assemblies is capable of selectively firing the sub-projectiles from selected divert propulsion barrels whereby said projectile is accelerated by the reactionary force generated by said firing of sub-projectiles.

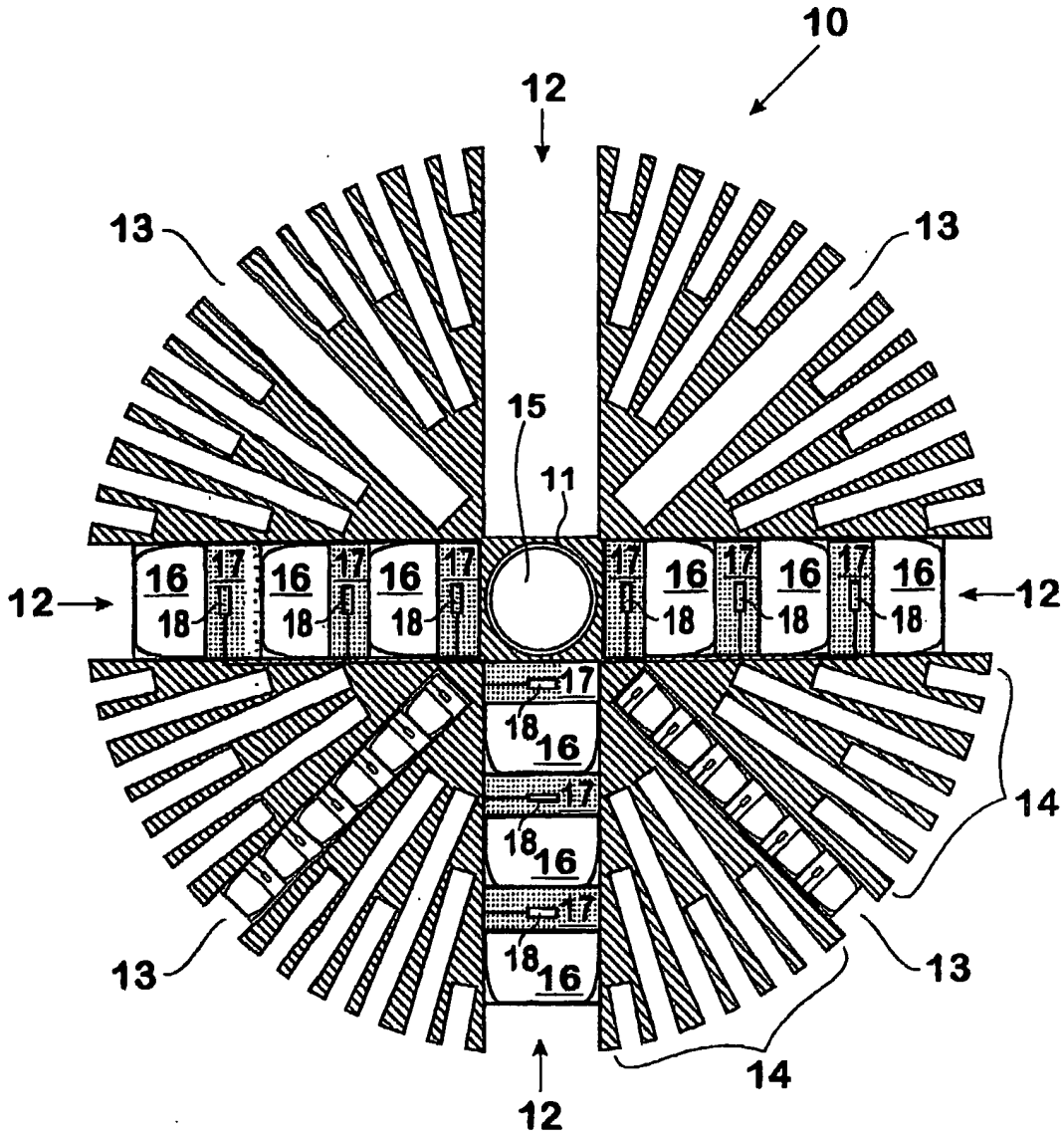


Fig. 1

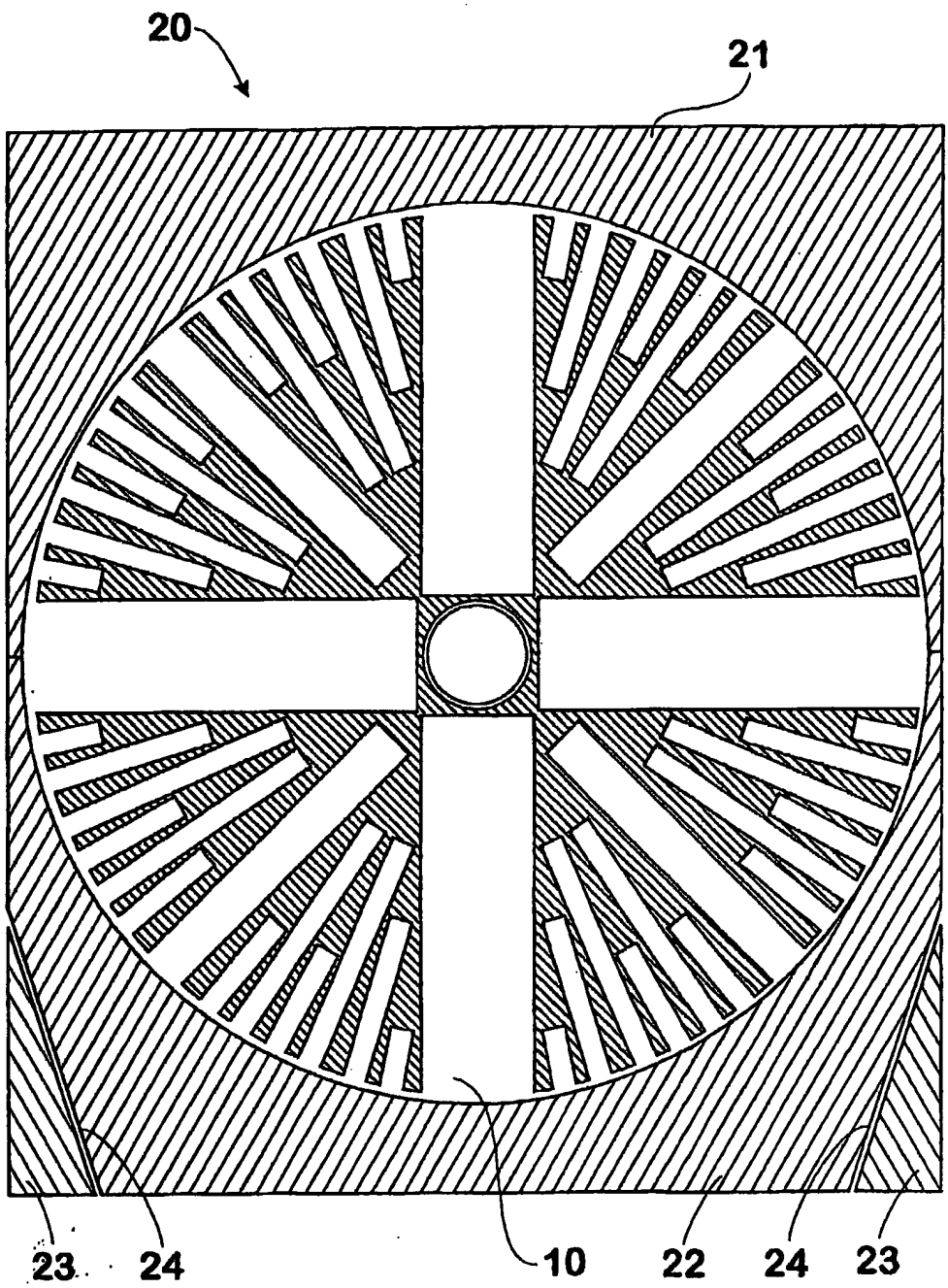
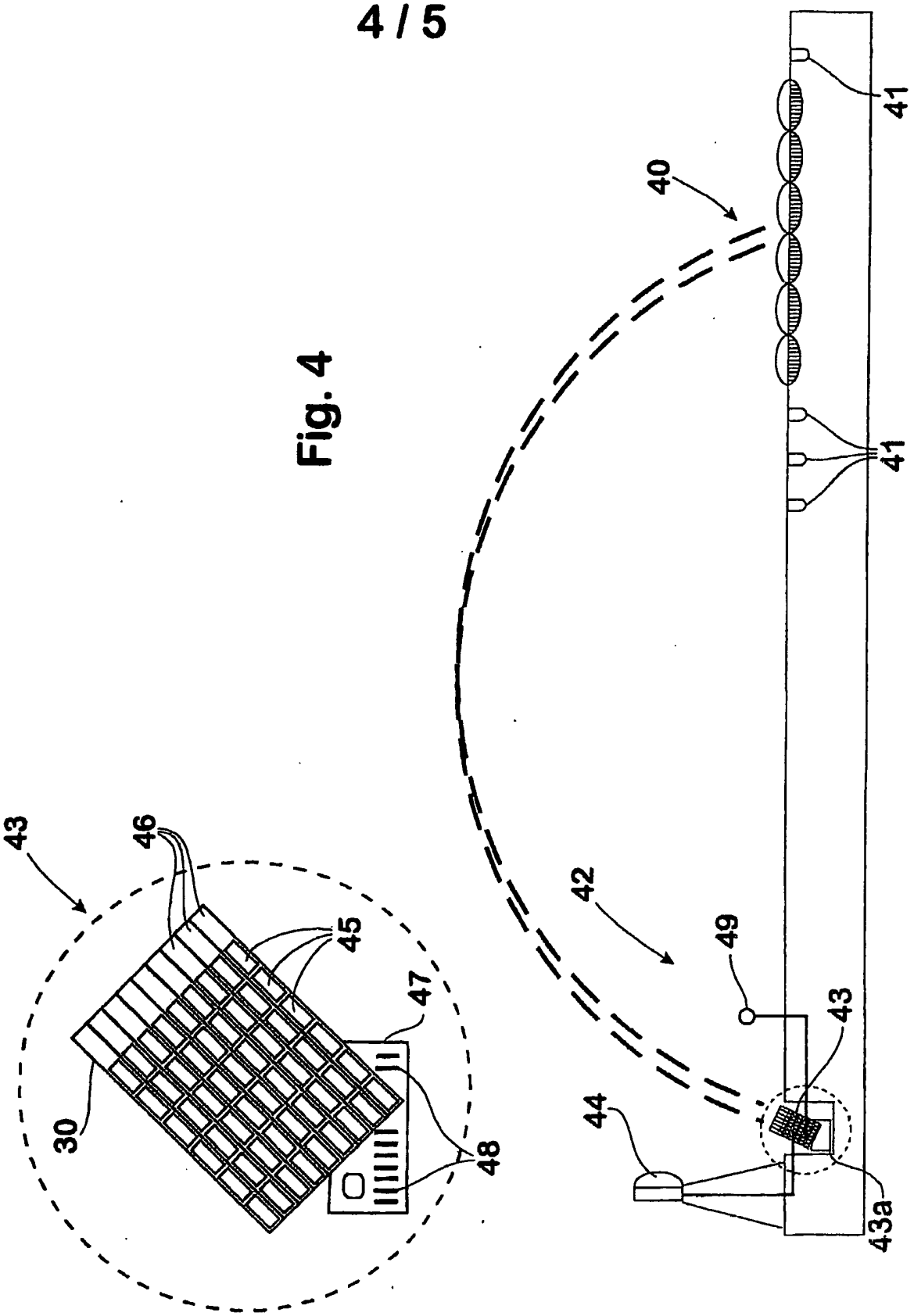


Fig. 2

Fig.3

Fig. 4



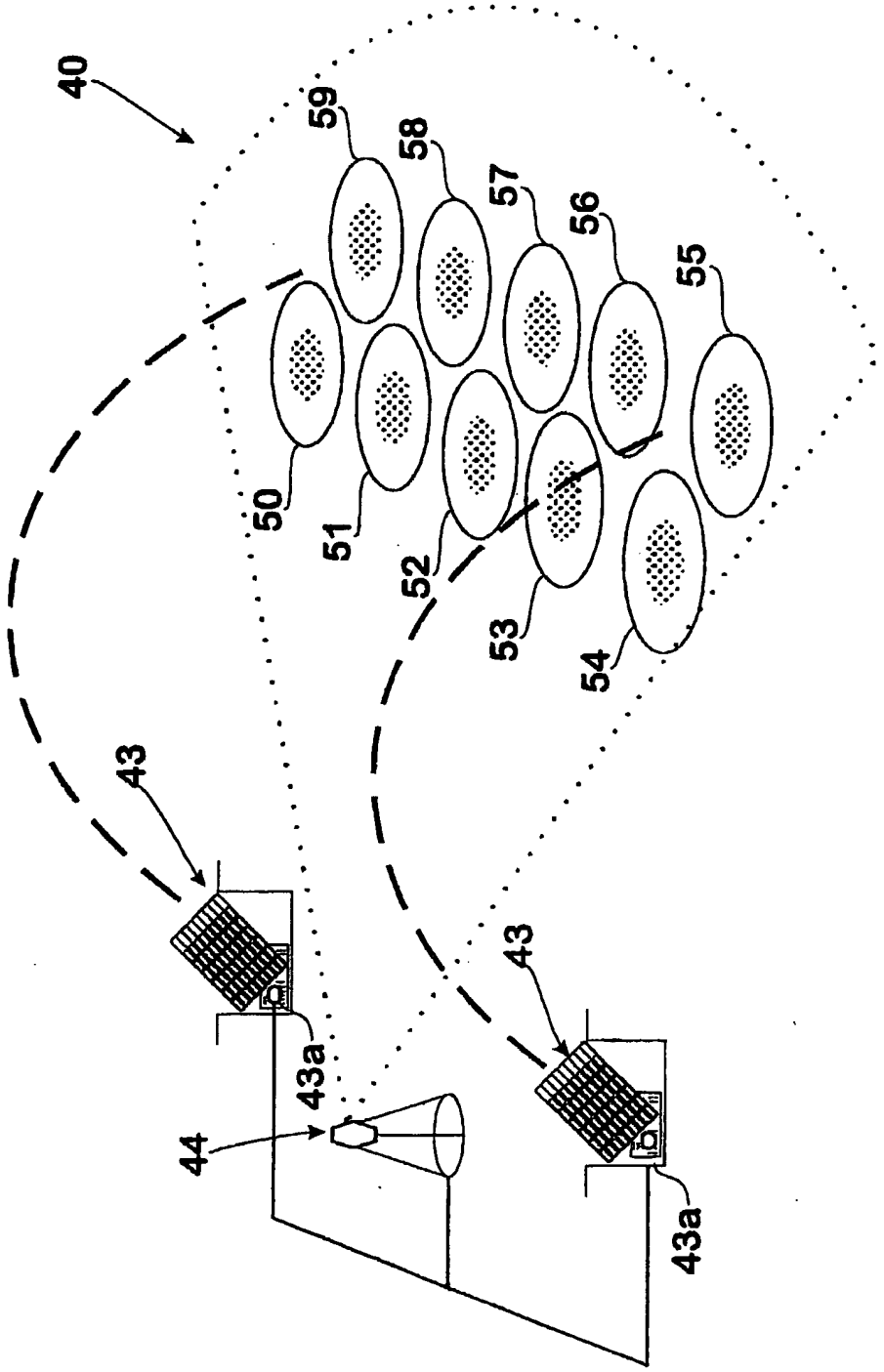


Fig. 5

I[redacted]NATIONAL SEARCH REPORT

International application No.
PCT/AU02/00909

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. [7]: F41H 11/02; F41F 1/00; F42B 12/48, 12/52, 12/60, 12/70, 4/24; A62C 3/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU: IPC F41H 11/02; F41F 1/00; F42B 12/48, 12/52, 12/60, 12/70, 4/24; A62C 3/02

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DWPI: Q79/DC with keywords such as projectile, sub-projectile, deploy and similar terms.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	AU 200210130 A (METAL STORM LIMITED) 3 December 2001	
P, X	Whole document	1-3, 8-13, 39
P, Y	Whole document	36-38
	AU 200140322 A (METAL STORM LIMITED) 31 July 2001	
P, X	Whole document	1-3, 8-16, 20-25, 30-33
P,Y	Whole document	36-38
	WO 00/52414 A (LINICK) 8 September 2000	
Y	Whole document	1-3, 8-13, 15, 20

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 October 2002	10 OCT 2002
Name and mailing address of the ISA/AU	Authorized officer
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	JEFFREY CARL Telephone No : (02) 6283 2543

Form PCT/ISA/210 (second sheet) (July 1998)

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	AU 64097/96 A (O'DWYER) 18 February 1997 Whole document	1-3, 8-13, 15, 20
A	EP 821215 A (TRW INC.) 28 January 1998	
A	DE 4209051 A (DEUTSCHE AEROSPACE AG) 23 September 1993	
A	GB 2245051 A (THOMSON-BRANDT-ARMEMENTS) 18 December 1991	
A	EP 395520 A (ETAT-FRANCAIS) 31 October 1990	

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
AU	200210130	WO	01/90682				
AU	200140322	WO	01/53770				
WO	00/52414	NONE					
AU	64097/96	BR	9609544	CA	2227066	CN	1193384
		EP	839310	US	6138395	WO	97/04281
EP	821215	US	6279482	JP	11-264699		
DE	4209051	NONE					
GB	2245051	DE	3808796	FR	2654822	IT	1235715
		SE	8800907				
EP	395520	FR	2646503				

END OF ANNEX